Association between Household Food Production Diversity and Minimum Dietary Diversity of Women in Rural Bangladesh: a Secondary Analysis from BIHS 2018-19

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Declaration

I, Apurbo Aham Apu, hereby declare that this thesis entitled "**Association between Household Food Production Diversity and Minimum Dietary Diversity of Women in Rural Bangladesh: a Secondary Analysis from BIHS 2018-19"** is an original work submitted in partial fulfilment of the requirements for the degree of Master of Public Health (MPH) at the James P. Grant School of Public Health (JPGSPH), BRAC University, Dhaka, Bangladesh.

I further declare that this work has not been submitted previously, in whole or in part, for any other degree or examination at this or any other university or institution.

All sources used in this thesis have been duly acknowledged and cited. Any assistance received has been mentioned in the acknowledgements section.

I have also added a separate declaration on GenAI use at the end of this work.

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Date: 3.6.2026

Approval

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Ethics Statement

This study is a secondary analysis of Bangladesh Integrated Household Survey (BIHS) 2018-19. The dataset is available in public domain. Hence, no ethical clearance was required to access the BIHS dataset. The ethical approval of the original survey was granted by Institutional Review Board of International Food Policy Research Institute (IFPRI) in Washington, DC, USA (Ref: 2014-44-PHND-D) and authorized by Ministry of Agriculture, Government of Bangladesh. As an MPH thesis, an approval for this study was obtained from the Institutional Review Board of BRAC JPGSPH on 22 February, 2026 (MPH-2025-001).

Abstract

Background: Despite advances in food production in the last decade, rural Bangladeshi women of reproductive age (15-49 years) still suffer from micronutrient deficiency due to inadequate dietary diversity. A growing number of literatures suggest a positive association between production diversity and dietary diversity of women in rural Bangladesh. However, evidence from Bangladesh remains limited on the association between production diversity and dietary diversity indicators, particularly at a national scale. This knowledge gap has important implications for national nutrition and agriculture policies and programmes.

Objectives: To investigate the association between household food production diversity and the dietary diversity among women of reproductive age 15-49 years in rural Bangladesh.

Methods: A quantitative, cross-sectional study was done using the data from the third round of Bangladesh Integrated Household Survey (BIHS, 2018-19). Non-pregnant, non-lactating rural women of reproductive age 15-49 years were included for the analyses (n=3687) with complete dietary, production and household level data. Women's dietary diversity was measured by Minimum Dietary Diversity of women (MDD-W) and dietary diversity score (WDDS). Production diversity was measured by Minimum Food Group Production Diversity (MFGPD) and Food Group Production Diversity Score (FGPDS) based on the same 10 food group as MDD-W. The survey weighted descriptive, bivariate and multivariate regression analyses were done to assess the association between dichotomous minimum food group production diversity with Minimum Dietary Diversity, whereas a secondary analysis using their continuous counterparts was done to assess robustness.

Results: The dietary diversity was low among the women in rural Bangladesh, with only 37% women achieving minimum dietary diversity with a mean score of 4.24. However, household food group-based production diversity was positively associated with dietary diversity, though the strength of the association was modest. Factors such as gender of the household head, household size, and wealth index were significant predictors of dietary diversity in both models, with land type and women's education emerging as additional significant predictors in secondary analysis.

Conclusions: Food consumption diversity among women in rural Bangladesh is low, suggesting persistent inadequate micronutrient intake. The relationship between dietary diversity of women and household food-group production diversity was positive but modest. This suggests that household food production diversification is not enough to enhance women's nutritional status. An integrated approach is required, and nutrition-sensitive agriculture programmes should combine production diversification with efforts to improve other associated factors, including women's access to nutritious foods, household consumption of produced foods, market access, financial affordability and women's involvement in food decision making.

Keywords: Dietary diversity, nutrition, women of reproductive age, production diversity, rural Bangladesh

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List of Acronyms

Acronyms	Full Form
AOR	Adjusted odds ratio
BDHS	Bangladesh Demographic and Household Survey
BIHS	Bangladesh Integrated Household Survey
CI	Confidence Interval
CAPI	Computer assisted personal interviewing
COR	Crude odds ratio
DATA	Data Analysis and Technical Assistance
FAO	Food and agricultural organization
FIES	Food insecurity experience scale
FGPDS	Food group production diversity score
IFPRI	International Food Policy Research Institution
IRB	Institutional Review Board
LMIC	lower-and-middle income countries
MDD-W	Minimum Dietary Diversity of Women of reproductive age
MFGPD	Minimum food group production diversity
OR	Odds ratio
PSU	Primary sampling unit
SDG	Sustainable Development Goal
UNICEF	United Nations Children's Emergency Fund

USAID	United States Agency for International Development
WHO	World Health Organization
WDDS	Women's Dietary Diversity Score
WRA	Women of reproductive age

Chapter 1: Introduction

1.1 Background and Rationale

Despite progress in global food production, dietary inadequacy still persists as a major public health challenge. According to the Global Nutrition Report (2022), almost one third of the world's population or approximately 2.3 billion people were moderately or severely food insecure in 2021, a direct outcome of inability to obtain nutritionally adequate, well-balanced food. Globally women of reproductive age are more vulnerable to essential micronutrient inadequacy especially in rural settings of lower- and middle-income countries in Africa and Asia (G. A. Stevens et al., 2022). Women living in South Asia suffer significant health problems due to various degrees of micronutrient deficit (FAO et al., 2019). While Bangladesh has made notable progress in food production in the last two decades, the burden of malnutrition is still evident especially in rural areas. According to Rahman et al., (2022), the prevalence of undernutrition among women of 15–49 years was 12.7% among rural women compared to 8.5% from urban areas. In rural Bangladesh women consume on average below the required food groups suggested by FAO and suffer more micronutrient deficiency (F. Ahmed et al., 2016; Nguyen et al., 2024; Sinharoy et al. 2017).

Micronutrient adequacy and diet quality especially among the women of reproductive age (15-49 years), as the nutrient requirement for this age is particularly important for fertility and the future offspring. Micronutrient deficits are linked to lack of diversified diet. To assess dietary diversity and micronutrient adequacy Minimum dietary diversity for women (MDD-W) is widely used as a key policy level indicator (FAO/FHI 360, 2016). The indicator is validated in multiple resource poor settings and shows a consistent and strong association between MDD-W and micronutrient adequacy in diet for women of reproductive age (Arimond et al., 2010). Studies in rural Bangladesh has consistently shown lower prevalence of MDD-W suggesting the lack of diverse diet consumed by rural women (Klemm et al., 2015; M. H. Islam et al., 2023; Roy et al. 2022; Shamim et al., 2016; Shaun et al., 2022; S. Islam et al., 2022).

In rural agrarian Bangladesh, most households depend on agriculture. The agricultural production in these households is often related to diet pattern by one of two distinct pathways: direct consumption of own production or income from sale of own produce to afford diverse diet (Ecker 2018; Hirvonen & Hoddinott, 2016; Jones 2017; Sariyev et al. 2020). However, dietary diversity

may not be the same for all household members reflecting a structural inequality (Alam et al., 2023; Bonis-Profumo et al., 2020; Guja et al., 2025). Such intra-household inequality is particularly significant in food insecure households, necessitating the need to assess dietary diversity of reproductive age women (Asma & Kotani, 2023b; Harris-Fry et al., 2017).

Although multiple studies on rural Bangladesh have already assessed the relationship between household food production diversity and diet, important gaps remain. Most studies assessed diversity across broad agricultural domains such as crop, fish ponds, livestock or homestead (B. N. Ahmed and Waibel 2019; H. Ali & Murshed-E-Jahan, 2025; Kabir et al., 2022; Khandoker et al., 2022; Alam et al., 2023; Uddin 2025), rather than using food groups that are directly linked with dietary diversity indicators. In addition, prior studies either tested the association of dietary diversity and food production diversity at household level or used different indicators of production diversity making the production-diet link inconsistent (Alam et al., 2023; Roy et al., 2022). A food group-based production diversity indicator will provide meaningful evidence regarding which food groups can be promoted for nutrition sensitive agriculture interventions (Buzigi et al., 2025). This study aims to address this gap by using the same 10 food group-based production diversity as MDD-W, enabling a direct way to assess the correlation between household food production diversity and women's dietary diversity in rural Bangladesh.

1.2 Problem Statement

Despite of agriculture production improvement in Bangladesh, dietary diversity of Bangladesh's rural women reproductive age groups is low. multiple studies have identified the determinants affecting consumption patterns of rural women, including household food production and diet. However, very few studies directly observed the effect of a meaningful food group-based production diversity on women's dietary outcomes, particularly at a national scale. This paper tries to fill this gap with the help of the data of BIHS 2018-19 of rural Bangladesh.

1.3 Study Objectives

13.1 Overall Objective

To explore whether household food production diversity is associated with the dietary diversity among women of reproductive age 15-49 years of rural Bangladesh.

13.2 Specific Objectives

1. To estimate the prevalence of minimum dietary diversity among women of reproductive age and describe household food-group production diversity in rural Bangladesh.
2. To assess the association between MDD-W and 10 food group-based household food production diversity in rural Bangladesh.
3. To assess the individual, household, and contextual factors associated with women's minimum dietary diversity in rural Bangladesh.

1.4 Structure of the Thesis

This thesis is organized into six chapters. Chapter 1 provides the introduction, background, and study objectives. Chapter 2 presents a comprehensive review of existing literature. Chapter 3 outlines the methodology used in this study. Chapter 4 presents the findings. Chapter 5 provides a discussion and interpretation of the results in light of existing evidence. Chapter 6 concludes the thesis with key conclusions, recommendations, and limitations.

Chapter 2: Literature Review

Small-scale agriculture is often the main source of food and income among rural households. Historically, agricultural policies and interventions were focused on increasing staple food production to improve nutrition and reduce hunger (Michler & Josephson, 2017). However, a recent shift focusing on agricultural interventions from nutritional perspective has led to diversification of food products beyond staples (Ruel, Quisumbing, and Balagamwala 2018). As a result, food production diversity has been widely proposed to improve diet quality (Fanzo et al., 2013; Guja et al., 2025).

Evidence from lower-middle-income countries suggest dietary diversity may be positively affected by farm production diversity and agricultural biodiversity (Jones 2017). Empirical evidence from Africa shows extensive link between production diversity and dietary diversity although the impact is minimal (Sibhatu and Qaim 2018). A large nationally representative data from Malawi production diversity was consistently positive with household diet irrespective of household wealth and social status (Jones et al., 2014). In a similar setting Koppmair et al., (2016) found that production diversity had a small but positive effect on dietary diversity and market access played a bigger role in diet. This is plausible in rural agrarian settings where household produce is sold in the market to buy diverse foods. Evidence from Central Tunisia also found a weak positive association between indicators of production diversity and women's diet, with women's education and wealth being dominant determinants of dietary diversity (Gaillard et al., 2022).

A growing body of literature also explored women specific pathway associated with production-diet relationship. This pathway includes how women's engagement in agriculture impacts decisions relevant to their nutritional outcome. A study in Timor-Leste found that women's empowerment is associated with food production and both were positively associated with better dietary diversity (Bonis-Profumo et al., 2021). In rural Bangladesh, women's dietary diversity is influenced by a range of factors alongside household food production. Multiple studies show that in rural agrarian settings, socioeconomic factors such as household size, wealth, land ownership, limited education, employment opportunities and women's empowerment can consistently predict dietary outcome (Harris-Fry et al., 2015; M. Ali et al., 2022; M. Islam et al., 2020; Alam et al., 2023; Prachee et al., 2025; Shourove et al., 2023). Furthermore, lack of crop diversification, market access, and exposure to negative shocks such as natural disasters or pandemics can reduce

dietary diversity by increasing food insecurity (Harris-Fry et al., 2015; M. Ali et al., 2022; M. Islam et al., 2020; Alam et al., 2023; Prachee et al., 2025). Interventions targeting these factors help to mitigate these effects. However, persistent challenges remain due to poverty, gender inequality, seasonality and regional disparities (A. Islam et al., 2018; A-Thorne-Lyman et al., 2009; Ayenew, et al., 2018; Stevens et al., 2016). The prevalence of inadequate diversity can persist for longer periods of time as rural women's diets are often dominated by grains and leafy vegetables with limited consumption to animal proteins (Na et al., 2016; Stevens et al., 2016). Some studies suggest interventions such as homestead food production, livestock ownership and women empowerment in agricultural initiatives can improve dietary diversity (Nath et al., 2025; Waid et al., 2023). These findings put emphasis on further exploring how production diversity and other different structural and contextual factors affect women's dietary diversity across national level.

Existing evidence on production diversity and dietary diversity from Bangladesh remains scarce. Few small-scale studies done in rural Bangladesh found positive association similar to African nations. A cross sectional study on small farm holder households found that while farm production increased the household dietary diversity, farmers reliance on production reduced when market is more accessible (Kabir et al, 2022). Another study done in southern Bangladesh reported that the relationship between production diversity and dietary diversity is mediated by market access and ecological stress (H. Ali & Murshed-E-Jahan, 2025b). Furthermore, a national level analysis by Alam et al., (2023) using BIHS panel data revealed that agricultural production diversification positively impacted individual dietary diversity but with different magnitude. The impact of production diversification was found higher among women and children than men warranting the need to explore production diversification on women's diet.

Although multiple regional and small-scale studies in Bangladesh explored socio-economic determinants of women's dietary diversity, there is limited empirical evidence that quantitatively captures the food production diversity and dietary outcome of reproductive age women from a national perspective. This study aims to assess the production-consumption relationship by using a 10 food group based dichotomous minimum production diversity indicator on a nationally representative survey.

Chapter 3: Methods

3.1 Study Design

This study is a quantitative, cross-sectional study using the data from the third round of Bangladesh Integrated Household Survey (BIHS), also known as BIHS 2018-19. BIHS 2018-19 was conducted by International Food Policy Research Institute (IFPRI), with Data Analysis and Technical Assistance (DATA) and USAID (IFPRI, 2020). BIHS collects detailed data on (1) plot-level agricultural production and practices, (2) dietary intake of individual household members, (3) anthropometric measurements (height and weight) of all household members, and (4) data to measure women's empowerment in agriculture index (IFPRI, 2020).

3.2 Study Area and Setting

BIHS is a nationally representative survey of rural households of Bangladesh that collected data from all 64 districts of Bangladesh (IFPRI, 2020).

3.3 Study Period

This study includes all nationally representative households from the BIHS dataset surveyed from November 2018 to April 2019 (IFPRI, 2020).

3.4 Study Population

3.4.1 Study Population

The BIHS 2018-19 covers 5604 households in 275 primary sampling units (villages) which is nationally representative of rural Bangladesh (IFPRI, 2020).

3.4.2 Inclusion and Exclusion Criteria

All Nationally representative households with completed interview are included into this study. Inclusion criteria:

- Women who were permanently residing in the household with valid 24 hours food consumption data.
- Non-pregnant and non-lactating women of reproductive age group (15-49 years)

- Complete information on relevant modules.

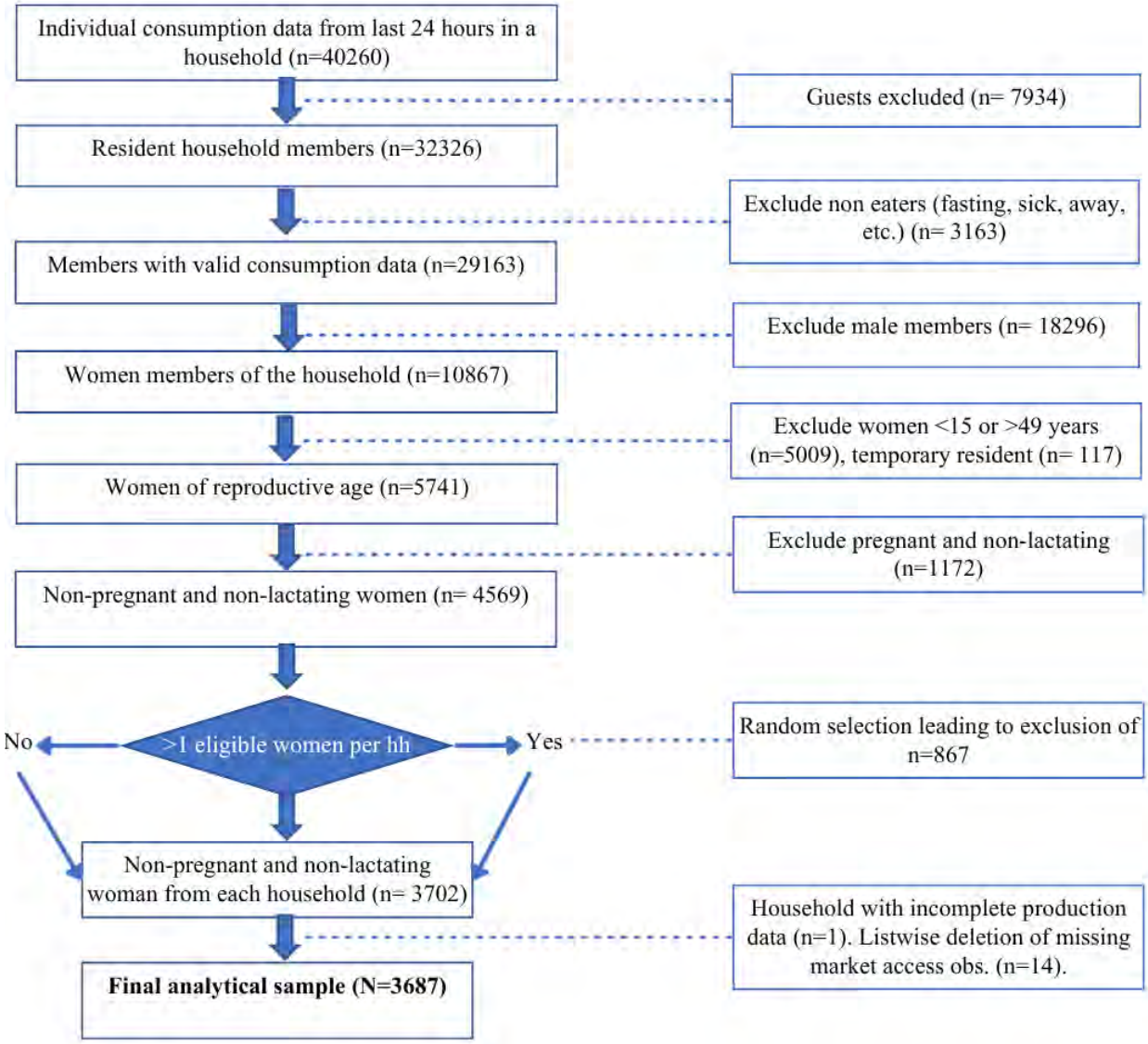
Exclusion criteria:

- Pregnant and lactating women.
- The recall period for food consumption fell on a special day (celebration or feast).
- Households with incomplete interview.
- Incomplete information on any relevant modules.

3.5 Sample Size Calculation

As the study is a secondary analysis of the BIHS 2018-19 survey, sample sizes were determined by the original survey rather than aligning with our current study objectives. Initially, all the permanent household members with valid 24 hours consumption data were selected from the individual consumption module. Afterwards, women aged 15-49 years old and non-pregnant and lactating were selected. Finally, one woman was randomly selected from each household with complete information on all relevant modules for the final analytical sample (N=3687). A summary of the analytical sample selection is provided in Figure 1.

Figure 1: Analytical sample selection for the study



3.6 Sampling Technique

A multi-staged, stratified probability sampling was used in the BIHS survey where rural areas were stratified by administrative division (Barishal, Chittagong, Dhaka, Khulna, Rajshahi, Rangpur & Sylhet). In the first stage, 275 primary sampling units (PSUs or villages) were allocated across the strata with probability proportional to size (number of households in each stratum). In the next stage, 20 households were randomly selected from each PSU. The survey used the 2001 population census of Bangladesh as the sampling frame and 2011 population census was applied for adjusting

the sampling weights. The sampling technique yielded a total number of 5604 households with completed interview (A. U. Ahmed et al., 2022).

3.7 Variables

3.7.1 Dependent Variable(s)

The primary outcome variable of our study is the women's dietary diversity. We will use two measures of dietary diversity, Minimum dietary diversity for women (MDD-W) and Women Dietary Diversity Score (WDDS).

MDD-W was constructed following the standardised methodology outlined in the *Minimum Dietary Diversity for Women: A Guide for Measurement* (FAO/FHI 360, 2016). Individual food consumption data from the 24-hour dietary recall module were used to classify all food items consumed into ten food groups: (1) grains, white roots, tubers, and plantains; (2) pulses; (3) nuts and seeds; (4) dairy; (5) meat, poultry, and fish; (6) eggs; (7) dark green leafy vegetables; (8) other vitamin A-rich fruits and vegetables; (9) other vegetables; and (10) other fruits. Non-food items and condiments (e.g., tea, spices, bay leaves) were excluded as they do not contribute to the food group score. A binary indicator was assigned for each food group (1 = consumed at least one item from that group with minimum 15g quantity; 0 = did not consume). Finally, dietary diversity score was computed (0-10) and a binary MDD-W indicator was created (1=YES, 0=NO). Women who consumed minimum 5 or more food groups out of the 10 food groups were classified as adequate MDD-W and coded as 1, if not then classified as inadequate MDD-W and coded as 0.

WDDS was computed by summing the number of food groups consumed by a woman out of the same 10 food groups as MDD-W (grain, starchy roots and tubers, and plantain; pulses; nuts and seeds; milk and milk products; meat, poultry, and fish; eggs; dark green leafy vegetables; other vitamin A rich fruits and vegetables; other vegetables and fruits) in the previous day (FAO, 2021). WDDS was measured as a continuous variable.

The primary analysis of the study used MDD-W to explore the association, whereas, WDDS was used as a secondary analysis for robustness.

3.7.2 Independent Variables

The main exposures of the study are food group production diversity scores (FGPD) and minimum food group production diversity (MFGPD). FGPDS was constructed as an unweighted count of food groups produced by the household during the last one year, based on reported crop production, livestock products, and fish cultivation. Food items were grouped according to the ten food groups used for constructing the MDD-W indicator to ensure comparability between household production diversity and women's dietary diversity. Non-food cash crops and items not included in the MDD-W food groups were excluded from the production diversity score. Condiments and seasonings, such as garlic, onion, and chilli, were also excluded because they are not considered food groups for assessing MDD-W. A household was considered to have achieved minimum food-group production diversity if it produced at least five out of the ten MDD-W food groups during the last one year. Therefore, MFGPD was coded as a binary variable: 1 = produced five or more food groups, and 0 = produced fewer than five food groups (Buzigi et al., 2025; FAO, 2021).

Based on existing theories and literature review there are several structural and contextual factors influencing the household and individual dietary diversity (Harris-Fry et al., 2015; Prachee et al., 2025; Roy et al., 2022; Stevens et al., 2016). We included several household level and individual level characteristics. Food insecurity experience scale (FIES) was created to identify household food security status and categorized into 2 categories (Food Secure/Mild insecurity, Moderate to Severe insecurity). Negative shock was defined as household facing any unexpected events in the last one year which had severe or worse economic and food impact and coded binary (1= yes; 0= no). Other important covariates include women's age, education, employment, marital status, participation to social safety net programs, household size, gender of the household head, education and employment of household head, wealth index, land type owned, access to sanitation facilities and market access.

Wealth quintile was calculated using total per capita household consumption expenditure. Initially, the total food and non-food expenditures, durable asset value and housing value were calculated separately. The expenditures of individual consumption items were aggregated to construct total

monthly expenditure. Then a total monthly consumption expenditure was created by summing up the components. Finally, households were ranked and divided into five equal groups based on per capita expenditure (A. U. Ahmed et al., 2022).

3.7.3 Operational Definitions

A list of important variables with their definition and source is provided in **Table 1**.

Table 1: Operational definition of variables.

Variable Name	Variable Type	Definition	Source
Minimum dietary diversity for Women (MDD-W)	Dependent	Percentage of women in reproductive age (15-49) who consume at least 5 out of 10 food groups (grain, starchy roots and tubers, and plantain; pulses; nuts and seeds; milk and milk products; meat, poultry, and fish; eggs; dark green leafy vegetables; other vitamin A rich fruits and vegetables; other vegetables and fruits) within the last 24 hours defined by FAO. Coded as binary (1 = ≥5 food groups).	(FAO. 2021).
Women's Dietary Diversity Score (WDDS)	Dependent	Counting the number of food groups consumed by a woman out of the same 10 food groups as MDD-W	(FAO. 2021).
Minimum food group production diversity (MFGPD)	Independent	Percentage of households producing at least 5 out of 10 food groups defined in MDD-W in last one year. We kept records of positive production quantity to get an overall idea of what household usually produces in a year. A woman was considered to have adequate MFGPD if her	(Buzigi et al., 2025; FAO, 2013)

		household produced at least 5 out of the 10 food groups. The FGPD score did not take into account condiments and seasonings such as garlic, onions, and hot pepper, among others, because they are not part of the food groups for assessing MDD-W.	
Household food group production score (FGPDS)	Independent	An unweighted count of the food crops produced, livestock products owned and fish cultivated and grouped according to FAO 12 food groups. Some of the farms also produce non-food cash crops (e.g., oil palm, tea etc.) that do not directly contribute to household dietary diversity and were excluded. This differentiation may be important from a nutrition perspective. Defined as a continuous variable.	(Buzigi et al., 2025; FAO, 2013)
Food Insecurity Experience Scale (FIES)	Independent	Food insecurity experience scale was created using an 8 item food insecurity questionnaire from the Food Insecurity module of BIHS. Responses were coded as "Yes=1", "No=2" and "Refused=3" and summed to generate raw FIES score on a scale of 0-8 where 0 means Food Secure. Raw scores were further categorized into 2 groups: Food Secure/Mild food insecure (0-3) Moderate/Severe food insecure (4-8	(Cafiero et al., 2017; Jubayer et al., 2023)
Land type owned	Independent	Land type owned by household. Coded into binary. 1= Homestead only 2 = Household operated cropland/aquaculture	(Harris-Fry et al., 2015)

Negative shocks	Independent	Any negative shock occurred in the past 12 months which severely impacted on food consumption or economy. Coded binary (1=Yes, No=0)	(Ansah et al., 2020; FA0, 2006)
Education	Independent	Defined as following: • No education (no schooling) • Primary • Secondary & Higher	(Prachee et al., 2025)
Occupation	Independent	Defined as following: • Agricultural & farm-based • Non-agricultural (Public, private, unskilled, factory, domestic, small shop owners, tailor, blacksmith, cobblers etc.) • Economically inactive (jobless, physically/mentally challenged, etc.)	(ADB, 2012; ILO, 2013; Osmani & Latif, 2013)
Wealth quintile	Independent	Constructed based on per capita consumption expenditure. The consumption aggregates food and non-food expenditures and is widely used as a proxy for income.	(A. U. Ahmed. et al., 2022; Friedman, 1957)
Social Safety Net	Independent	Defined as women receiving any support from social safety net programs. Binary (0=No; 1=Yes)	(Olney et al., 2022)
Market access	Independent	Market access was measured as self-reported distance (km) and travel time (minutes) from the household to the nearest weekly or periodic bazar (haat). Most valid distances are <5 km and travel times <30 min. So, the access was categorized as following: • High access (≤1 km / ≤10 min),	(Islam, A. et al., 2018; Usman et al., 2022)

		• Moderate access (1–2 km / 10–20 min) • Low access (>2 km / >20 min). This definition is consistent with food environment research in rural Bangladesh.	
Improved sanitation	Independent	In this study, we have defined improved sanitation (basic) according to JMP by WHO and UNICEF as follows: an improved sanitation facility is "one that hygienically separates human excreta from human contact" and that is not shared with other households. "1" indicating improved sanitation (both improved toilet facility and not shared toilet) and "0" indicating not improved sanitation (either not improved toilet facility or shared toilet).	(WHO, 2017)

3.8 Data Collection

3.8.1 Data Collection Tools

A gender disaggregated household questionnaire was deployed during the primary data collection to collect household level and individual level information from both primary male and female respondents, who were interviewed separately. Interviews of male participants were conducted by male interviewers and female participants by female interviewers. A computer assisted personal interviewing (CAPI) system was used by the survey team to ensure data quality, reducing recording errors and allow real time validation of responses in the field.

3.8.2 Pretesting

This study was based on a secondary analysis of BIHS 2018-19, so no pretesting of data collection tools was conducted by the researchers. The original survey tools were pretested by IFPRI researchers and DATA (Data Analysis and Technical Assistance) Ltd. prior to field

implementation. For the current analysis, an initial data familiarization phase was conducted by reviewing original questionnaire to understand how variables were operationalized and responses were coded. Furthermore, codebook was reviewed to understand variable and missing value codes. Prior to the main analysis, a preliminary frequency distribution and cross tabulation was done to check for data anomalies, unexpected distribution and coding inconsistencies.

3.8.3 Data Collection Procedure

For the present study, BIHS 2018-19 dataset was downloaded from Harvard dataverse which is a public domain (IFPRI, 2020). Multiple modules relevant to study were extracted from the larger dataset for the analysis. A list of the relevant modules used for this study are mentioned in the Appendix .

3.9 Data Management and Quality Assurance

After obtaining the dataset, data management was performed. Working datasets were created from the raw datasets. Variables were recoded and new variables were constructed as required by the study objectives. Recoded variables were cross checked against the original codebook and available literature. Households facing negative shocks were initially created as a categorical variable with 4 categories (No severe shock, severe economic impact only, shocks severe food impact only, both food and economic impact). However, such disaggregation was not feasible as severe food shocks only accounted for 8 observations (0.22% of the final sample). Furthermore, a significant number of households reported both economic and food impacts (n=820, 22%) indicating that both impacts are structurally inseparable. As a result, the categories were collapsed into binary (1=any shocks with severe food or economic impact, 0=no severe shock). Market access could not be classified for 14 households (0.38% of the sample) due to missing or internally inconsistent travel time and distance. Complete case analysis was conducted and the observations were dropped following listwise deletion. Sensitivity analysis confirmed that dropped observations didn't differ systematically from the analysis sample on key characteristics. The final effective sample size was 3687 on the outcome examined. All analysis were conducted using statistical software STATA v.17 S. E (Stata Corporation, College Station, TX, USA).

3.10 Data Analysis

The BIHS 2018-19 dataset is modular in nature. All socio-demographic, agricultural and environmental information were extracted from the corresponding male and female modules. We constructed our outcome variables from the food consumption modules. All analyses were accounted for the complex survey design of BIHS, by using survey sampling weights. In our analysis, household weight (hhweight) was applied keeping the village (vcode) as PSU and division (dvcode) as the sampling stratum. Weighted estimates were used to reflect the rural national representativeness. The primary analysis used the binary outcome MDD-W. A secondary analysis using WDDS was used to measure the association across two different measures to determine the consistency of the findings.

Descriptive analysis was conducted to summarize the characteristics of women and their households. Weighted frequencies and percentages were reported for categorical variables, while weighted means with standard errors or 95% confidence intervals were reported for continuous variables. The distribution of household food-group production diversity, mean WDDS, and the proportion of women achieving MDD-W were also described.

Bivariate analyses were conducted to describe the crude association between each independent variable and MDD-W. Survey-weighted Rao–Scott adjusted chi-square tests were used for categorical variables, while survey weighted linear regression for continuous variables. The continuous variables were checked for linearity with fractional polynomial for choosing the correct parametrization. These bivariate analyses were used mainly to understand the distribution and crude relationships between variables, rather than as the sole basis for selecting variables for the final model.

The primary analysis used survey-weighted binary logistic regression to assess the association between minimum food-group production diversity and MDD-W. The main exposure variable, minimum food-group production diversity, was retained in all models regardless of its statistical significance. For the multivariable analysis, a theory-driven modelling approach was adopted. Covariates were identified a priori based on the existing literature, and biological or programmatic relevance. These covariates represented structural, household, and individual-level factors that

could plausibly confound the relationship between household production diversity and women's dietary diversity. They included women's age, education, marital status, employment status, social safety net participation, gender of the household head, household size, household wealth, household food insecurity, household land ownership, household head's education and employment, exposure to negative shocks, sanitation facilities and market access,.

All theoretically relevant covariates were entered into the multivariable model, and variables were not removed solely because they were statistically non-significant in bivariate or multivariable analyses. This approach is consistent with epidemiological best practice, which prioritises theoretical grounding and reduces the risk of omitting substantively important confounders that may not reach conventional statistical significance thresholds in unadjusted analyses (Greenland, 1989; Rothman et al., 2008). Before fitting the final model, selected variables were assessed for multicollinearity.

A survey-weighted binary logistic regression model was fitted for the primary outcome, MDD-W, with all pre-specified covariates entered in a single block. Adjusted odds ratios, 95% confidence intervals, and p-values were reported from the final logistic regression model. A two-sided Wald test was used to assess statistical significance. Potential interaction terms between the main exposure and selected theoretically relevant predictors were checked at $p<0.05$. Then the final model was tested for goodness of fit using survey weighted Archer-Lemeshow test (Archer & Lemeshow, 2006).

As a secondary analysis, survey-weighted linear regression was conducted using WDDS as a continuous outcome. This analysis assessed whether the direction and consistency of the association between household food-group production diversity and women's dietary diversity remained similar when dietary diversity was measured as a score rather than as a binary indicator. Regression coefficients, 95% confidence intervals, and p-values were reported. A p-value of <0.05 was considered statistically significant in the final multivariable analyses.

3.11 Ethical Considerations

The BIHS 2018-19 dataset is available in the public domain. No ethical clearance is required to access the BIHS database. The Institutional Review Board at the International Food Policy Research Institute (IFPRI) in Washington, DC, USA (Ref: 2014-44-PHND-D) granted BIHS ethical approval. The survey questionnaire of BIHS is reviewed and authorized by The Ministry of Agriculture, Government of Bangladesh. The dataset used for this study contains no identifiable information and fully anonymized and the researchers had no direct contact with the respondents and no role in data collection. The secondary analysis poses minimal risk to the respondents and the analyses were conducted at aggregate level. No attempt was made to identify any households or individuals. As this is an MPH thesis work, an approval for this study was obtained from the Institutional Review Board of BRAC JPGSPH on 22 February, 2026 (MPH-2025-001).

Chapter 4: Results

4.1. Sample Characteristics

Table 2 shows a brief summary of the sample characteristics. The mean age of reproductive age women was 32.86 (±0.15) years. Among the different age group, 21.15% women were aged 15-24 years, 33.074% were aged 25-34 years and 45.773% were aged 35-49 years. Looking across other characteristics, 82.62% women were married and 5.54% women participated in any social safety programs. Education level wise, 27.40% completed primary education and 46.89% women had completed secondary education or above. Employment wise nearly half of the women (46.20%) were involved in agricultural and farm-based work (Table 2).

The mean size of the households is (4.23 ± .04). The primary decision maker of 80.50% households is male. Forty two percent of the household head had no formal education. Almost half (51.21%) of the household head's occupation was agricultural and farm-based works (Table 2). In terms of land assets, 60.5% households had owned cropland or aquaculture. Looking at the food insecurity status, 14.30% households experienced moderate to severe food insecurity and 29% experienced negative shocks in the past one year (Table 2). In terms of access to facilities, 68% women had households with improved sanitation facilities and 64% had good market access (<1 km OR <10 min). Finally, division wise distribution of the sample population was mostly proportionate to the national distribution. (Table 2).

Table 2: Individual and household characteristics of the sample.

Variables	N=3687	Proportion (%) or Mean (weighted)	95 % CI
Women's characteristics			
Age group			
15-24 years	812	21.15	19.85, 22.52
25-34 years	1,212	33.07	31.49, 34.70
35-49 years	1,663	45.77	44.20, 47.35

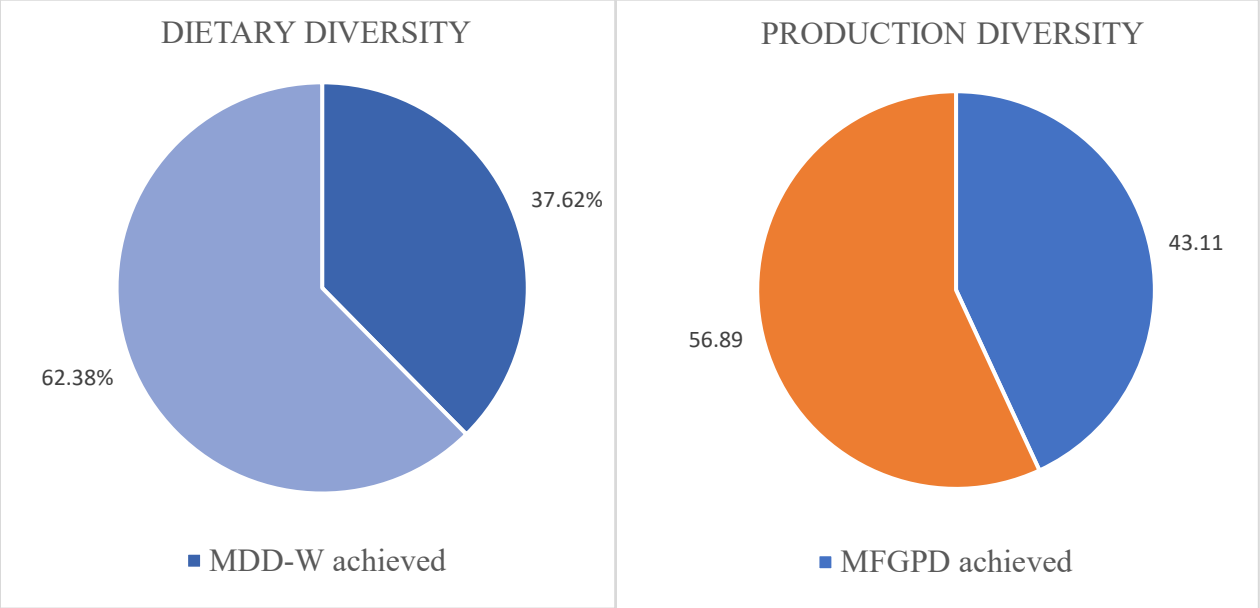
Women's Education			
No education	942	25.71	23.80, 27.71
Primary	1,020	27.40	25.85, 29.01
Secondary & Higher	1,725	46.89	44.83, 48.97
Women's Employment			
No employment	1,691	44.45	42.43, 46.48
Agri & farm based	1,644	46.20	44.05, 48.37
Non agricultural	352	9.35	8.22, 10.61
Women's Marital status			
Unmarried/Divorced/Separated	700	17.39	16.15, 18.70
Married	2,987	82.62	81.30, 83.85
Woman participated in any SSN program			
No	3,474	94.45	93.46, 95.31
Yes	213	5.55	4.69, 6.54
Household characteristics			
Gender of Household head			
Male	2,935	80.50	78.78, 82.05
Female	752	19.53	17.95, 21.22
Household size	3687	4.23	4.160, 4.29
Food Insecurity Experience Scale (FIES)			
Food secure/mild insecurity	3,111	85.70	83.81, 87.41
Moderate/Severe FI	576	14.30	12.59, 16.19
Land type owned by household			
Homestead only	1,525	39.54	36.99, 42.15
Household operated cropland or aquaculture	2,162	60.46	57.85, 63.01
Household head education			
No Education	1,533	41.75	39.60, 43.92
Primary	1,007	26.80	25.23, 28.43
Secondary & Higher	1,147	31.45	29.55, 33.43)

Household head employment			
No employment	390	9.67	8.55, 10.91
Agricultural & farm-based	1,840	51.21	48.68, 53.75
Non-Agricultural	1,457	39.11	36.71, 41.58
Household Wealth Index			
Q1	669	18.94	17.12, 20.90
Q2	738	20.12	18.72, 21.60
Q3	742	20.19	18.92, 21.53
Q4	783	20.95	19.54, 22.43
Q5	755	19.81	18.28 , 21.42
Any severe shock in last 12 months			
No	2,577	70.76	68.65, 72.78
Yes	1,110	29.24	27.22, 31.35
Sanitation facilities			
No improved	1,181	32.10	29.83, 34.46
Improved	2,506	67.90	65.54, 70.17
Market access category			
High access <1 km or <10 min	2,361	64.06	60.15, 67.79
Moderate access (1-2 km OR 10-20 min)	997	26.68	23.73 , 29.86
Low access (>2 km AND >20 min)	329	9.26	7.54, 11.31
Division			
Barishal	261	5.50	5.11, 5.87
Chittagong	683	18.23	17.24, 19.25
Dhaka	1,089	29.94	28.71, 31.20
Khulna	365	12.34	11.31, 13.44
Rajshahi	412	15.15	14.22 , 16.13
Rangpur	352	12.43	11.33, 13.63
Sylhet	525	6.44	6.02, 6.88

4.2. Prevalence of dietary diversity, variation in food consumption and production pattern

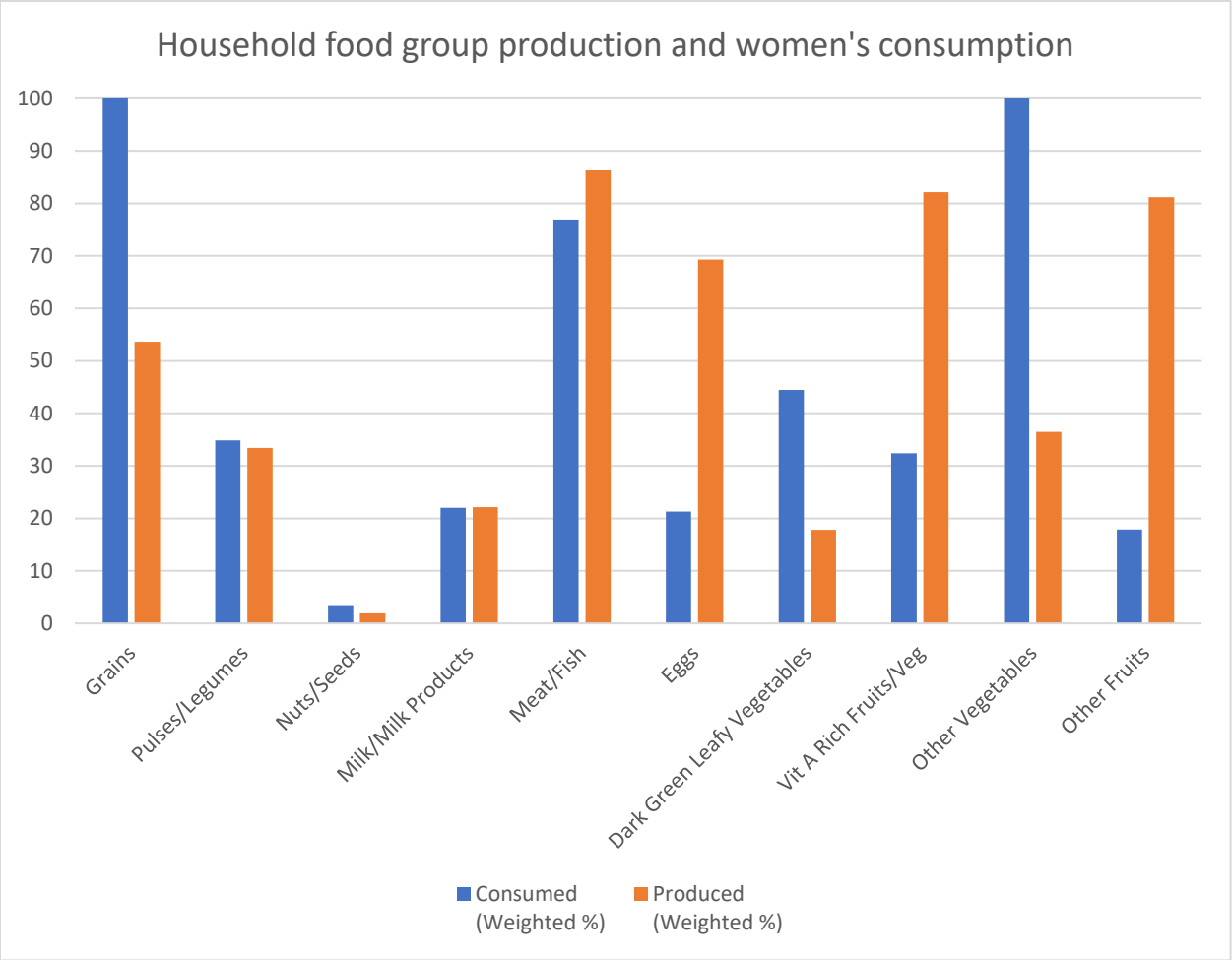
The mean dietary diversity score of the sample population is 4.24(±0.03) food groups (Table 2). Nearly a quarter (37.62%) of the women of reproductive age achieved MDD-W (Figure 2). The prevalence of minimum food group production diversity achieved was 43.11% (Figure 2) and food group production diversity score is 4.10(±.064) food groups.

Figure 2: Distribution of minimum dietary diversity of WRA (MDD-W) and minimum food group production diversity (MFGPD)



A survey weighted Rao-Scott adjusted Pearson chi-square test was done to see the association between specific food group production and its consumption. Figure 3 compares women's consumption of the ten MDD-W food groups with household production of the same food groups. A huge difference was found between egg production and consumption. Nearly 70% of households produce eggs but fewer than 1 in 5 women consumed eggs in the last 24-hour recall. Similarly, consumption of other fruits was significantly less than the production (17.9% vs 81.2%, p=0.0017). On the contrary, consumption of dark green leafy vegetables was significantly higher than household production (p = 0.036).

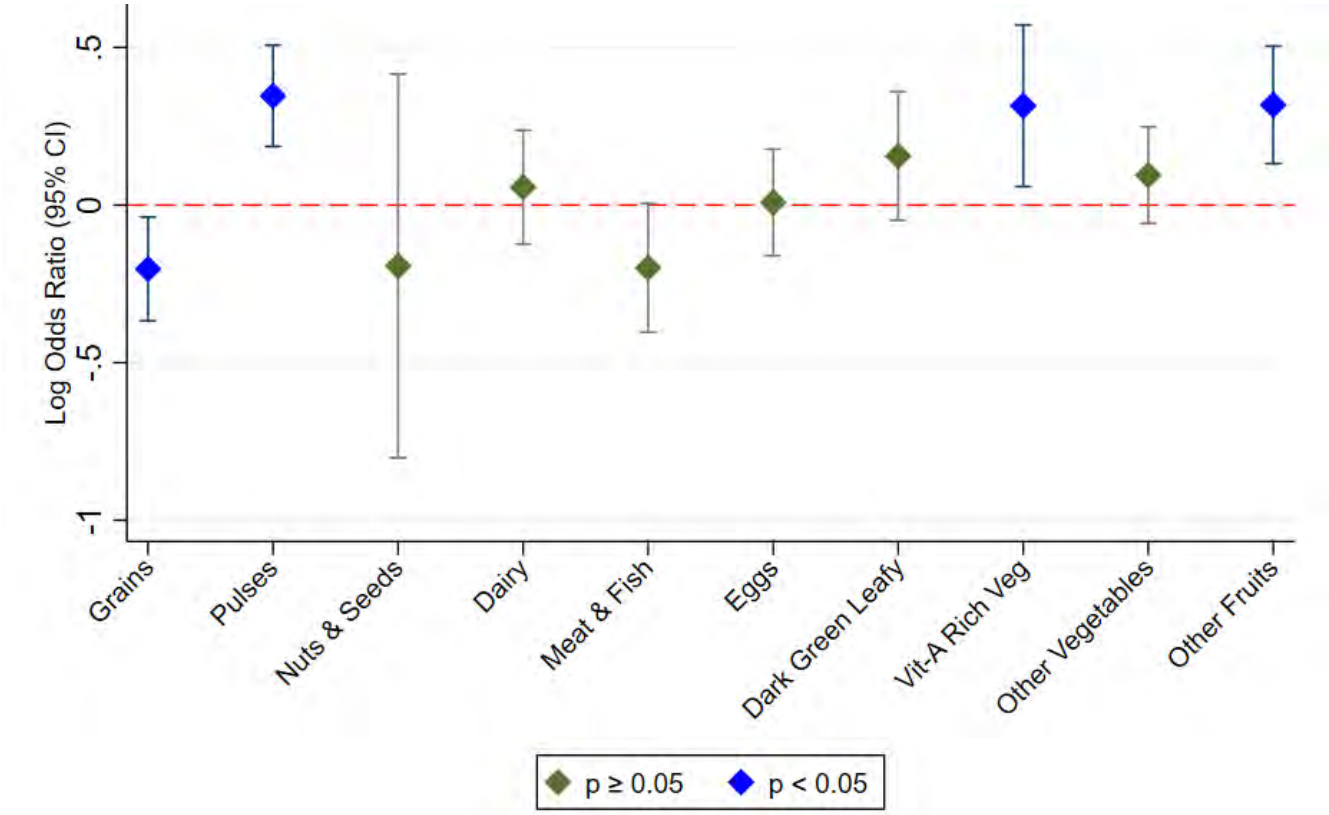
Figure 3: Proportion of food group production and women's consumption of the 10 food groups



***Note**: Graph shows association between food group consumed and same food group produced. A survey weighted Rao-Scott adjusted Pearson chi-square test accounting for complex survey design to. Statistical significance set <0.05,*

Furthermore, the prevalence of women achieving MDD-W when each food group was produced in the household was explored by survey weighted bivariate logistic regression. Overall, production of pulses, vitamin A rich fruits/ vegetables and other fruits were positively associated with achieving MDD-W (Figure 4). On the contrary, grain producers had lower odds of achieving MDD-W. Households producing nuts, dark green leafy vegetables, other vegetables and animal source production such as dairy, meat-fish and eggs show weaker association than the rest food groups with achieving MDD-W (Figure 4).

Figure 4: Prevalence of achieving MDD-W according to household food group production.



***Note**: Forest plot showing log transformed unadjusted odds ratio (OR) with 95% CI for the association between food group production and MDD-W. P values were derived from survey weighted bivariate logistic regression tests between MDD-W and food groups produced. Statistical significance set at p< 0.05.*

4.3. Production diversity, food insecurity and wealth index

Survey-weighted binary logistic regression was used to assess the crude association between minimum food-group production diversity (MFGPD) and household food insecurity and wealth quintile (Table 3). We observed a linear relationship between production diversity and household food security. The proportion of households achieving MFGPD declined with increasing severity of food insecurity. Compared with food-secure households, moderate to severely food-insecure households had 34% lower crude odds of achieving minimum food-group production diversity. The relationship between household wealth and MFGPD was not linear. The prevalence of MFGPD was lowest among the poorest households (37.85%) and highest among households in the second and middle wealth quintiles, at 46.63% and 46.45%, respectively. The prevalence then

declined among richer and richest households, with 44.38% of households in the fourth quintile and 39.85% of households in the richest quintile achieving MFGPD.

Table 3: Association of production diversity with food insecurity and wealth quintile

Category name	MFGPD achieved in each category n (%)	COR	95% CI	P-value
Food Insecurity Experience Scale				
Food secure/Mild insecurity	873 (44.55)	1.00	-	-
Moderate to severe food insecurity	206 (34.53)	0.66	0.53, 0.82	<0.01
Wealth Index				
Q1	251 (37.85)	1.00	-	-
Q2	344 (46.63)	1.43	1.14, 1.81	<0.01
Q3	339 (46.45)	1.42	1.13, 1.79	
Q4	347 (44.38)	1.31	1.02, 1.69	
Q5	300 (39.85)	1.08	0.84, 1.41	

***Note**: Overall associations were assessed using survey weighted adjusted Wald tests. Linear trend was assessed across categories by modelling the categorical variable in continuous form. Food insecurity was significantly associated with MFGPD (overall $p<0.001$). Wealth quintile was also significantly associated with MFGPD but no linear trend observed (overall $p<0.001$, linear trend $p=0.863$).*

4.4. Association between minimum dietary diversity and minimum food group production diversity in rural Bangladesh

Table 4 presents the results of both the bivariate and multivariate logistic regression analysis to explore the association between minimum food-group production diversity (MFGPD), selected individual and household characteristics, and women's minimum dietary diversity (MDD-W). Household that produced minimum 5 food groups or more were more likely to have women

achieving MDD-W (COR 1.20;95% CI 1.02- 1.42). Similarly, women who completed secondary or above education (COR 1.89, 95% CI: 1.57 - 2.29) and belonged to female-headed households (COR 1.19; 95% CI: 1.00 - 1.43) had better odds of achieving MDD-W. On the contrary, both women (COR 0.79; 95% CI: 0.68-0.93) and household head (COR 0.61, 95% CI: 0.48 -0.78, $p<0.001$) who were engaged in agricultural work were less likely to achieve MDD-W. Women who were married (COR 0.83, 95% CI: 0.69-1.00), social safety net beneficiary (COR 0.77; 95 % CI: 0.57 - 1.05), or belong to moderate to severe food insecure households (COR 0.63: 95 % CI: 0.51 - 0.79) were negatively associated with MDD-W as well.

Household wealth showed the strongest association with MDD-W. Only 17.31 % of women from the poorest households achieved MDD-W, compared with 58.72% of women from the richest households. Women from the richest households had more than six times higher crude odds of achieving MDD-W compared with women from the poorest households (COR: 6.795; 95% CI: 5.318 - 8.682). Improved sanitation access was positively associated 35% higher odds of meeting MDD-W (COR: 1.36; 95% CI:1.16, 1.60). Market access also saw significant association as odds of achieving MDD-W was 27 % less among low access households compared to high access households (COR 0.73; 95% CI: 0.54, 0.98, p=0.04).

Table 4: Factors associated with MDD-W of women of reproductive age in rural Bangladesh

Variable	MDD-W achieved n (%)	Crude OR	95% CI	P value	Adjusted OR	95% CI	P value
MFGPD ≥ 5 food groups produced							
No	799 (35.75)	1.00 (ref)	-	-	1.00 (ref)	-	-
Yes	670 (40.1)	1.20	1.02, 1.42	0.03	1.34	1.12, 1.60	<0.01
Food Insecurity Experience Scale							
Food secure/mild FI	1,278 (39.09)	1.00 (ref)	-	-	1.00 (ref)	-	-
Moderate/Severe FI	191 (28.87)	0.63	0.51, 0.79	<0.01	1.01	0.86, 1.36	0.51
Age group							
15-24 years	339 (39.9)	1.00 (ref)	-	-	1.00 (ref)	-	-
25-34 years	495 (37.99)	0.92	0.75, 1.14	0.45	1.17	0.91, 1.50	0.22
35-49 years	635 (36.31)	0.86	0.72, 1.02	0.09	1.11	0.87, 1.41	0.40
Women's Education							
No education	298 (29.48)	1.00 (ref)	-	-	1.00 (ref)	-	-
Primary	368 (34.02)	1.23	1.01, 1.51	0.04	0.97	0.78,1.22	0.82
Secondary & Higher	803 (44.19)	1.89	1.57 - 2.29	<0.01	1.17	0.92, 1.50	0.20
Women's Employment							
No employment	722 (40.39)	1.00 (ref)	-	-	1.00 (ref)	-	-
Agri & farm based	611 (34.98)	0.79	0.68, 0.93	0.02	0.99	0.81, 1.20	0.88
Non agricultural	136 (37.56)	0.89	0.69, 1.14		0.99	0.75, 1.28	0.87
Marital status							
Unmarried/Divorced/Separated	300 (41.23)	1.00 (ref)	-	-	1.00 (ref)	-	-
Married	1,169 (36.87)	0.83	0.69, 1.00	0.05	0.83	0.66, 1.04	0.11
Woman participated in any SSN program							
No	1,396 (37.95)	1.00 (ref)	-	-	1.00 (ref)	-	-

Yes	73 (32.03)	0.77	0.57, 1.05	0.1	0.83	0.59, 1.17	0.29
Gender of Household head							
Male	1,148 (36.80)	1.00 (ref)	-	-	1.00 (ref)	-	-
Female	321 (41.02)	1.19	1.00, 1.43	0.05	1.32	1.05, 1.65	**0.02**
Household size	3687	1.12	1.08, 1.17	<0.01	1.20	1.13, 1.27	**<0.01**
Land type owned by household							
Homestead only	638 (39.32)	1.00 (ref)	-	-	1.00 (ref)	-	-
Has operated crop or aquaculture land	831 (36.51)	0.89	0.76, 1.04	0.13	0.91	0.75, 1.10	0.33
Household head education							
No Education	511(31.27)	1.00 (ref)	-	-	1.00 (ref)	-	-
Primary	408 (37.82)	1.34	1.13, 1.59	<0.01	1.09	0.90, 1.32	0.36
Secondary & Higher	550 (45.89)	1.86	1.56, 2.23	<0.01	1.12	0.91, 1.39	0.28
Household head employment							
No employment	185 (45.43)	1.00 (ref)	-	-	1.00 (ref)	-	-
Agricultural & farm-based	650 (33.65)	0.61	0.48, 0.78	<0.01	0.86	0.64, 1.15	0.30
Non-Agricultural	634 (40.90)	0.83		0.17	1.11	0.81, 1.51	0.51
Household Wealth Index							
Q1	128 (17.31)	1.00 (ref)	-	-	1.00 (ref)	-	-
Q2	232 (28.9)	1.94	1.48, 2.55	<0.01	1.98	1.49, 2.63	**<0.01**
Q3	282 (36.37)	2.73	2.09, 3.56	<0.01	2.86	2.17, 3.79	**<0.01**
Q4	372 (45.63)	4.00	3.14, 5.13	<0.01	4.36	3.36, 5.66	**<0.01**
Q5	455 (58.72)	6.79	5.32, 8.68	<0.01	8.31	6.25, 11.04	**<0.01**
Any severe shock in last 12 months							
No	984 (36.62)	1.00 (ref)	-	-	1.00 (ref)	-	-
Yes	485 (40.06)	1.18	1.00, 1.35	0.06	1.02	0.87, 1.20	0.77
Improved sanitation							
No improved	417 (32.77)	1.00 (ref)	-	-	1.00 (ref)	-	-

Improved	1,052 (39.92)	1.36	1.16, 1.60	<0.01	0.96	0.81, 1.14	0.68
Market access category							
High access <1 km or <10 min	984 (39.57)	1.00 (ref)	-	-	1.00 (ref)	-	-
Moderate access (1-2 km OR 10-20 min)	369 (34.79)	0.82	0.67, 0.99	0.04	0.85	0.71, 1.02	0.10
Low access (>2 km AND >20 min)	116 (32.37)	0.73	0.54, 0.98	0.04	0.86	0.64, 1.15	0.30

***Note**: Logistic model for MDD-W. Unadjusted OR estimated from separate bivariate logistic regression analysis for each variable. Adjusted coefficient estimated from multivariable logistic regression model. 95% CI and p-values are reported for both unadjusted and adjusted models. No multicollinearity detected (VIF < 5). Total number of observations = 3,687; All estimates are survey weighted. goodness-of-fit test F(9,260) = 1.75; Prob > F = 0.0776. Statistical significance set at p <0.05.*

After adjusting for potential confounders, the positive association between MFGPD and MDD-W remained significant. Women of households that achieved MFGPD were associated with 34% higher odds of achieving MDD-W compared with households who didn't achieve MFGPD (AOR: 1.34; 95% CI 1.12, 1.60; p<0.01). Wealth also remained as a significant factor of dietary diversity as women of wealthiest households had more than 8 times higher odds of meeting MDD-W (AOR: 8.31;95% CI; 6.25, 11.04; p<0.001). Women of female headed households had 32% higher odds of achieving MDD-W (AOR 1.32; 95% CI1.05, 1.65; p = 0.02). Household size was positively associated with MDD-W. Each additional household member was associated with 20% higher odds of achieving MDD-W (AOR: 1.20; 95% CI: 1.13, 1.27; p < 0.01). The final model showed acceptable fit based on the goodness-of-fit test (F(9,260) = 1.75; p = 0.0776).

4.5. Secondary analysis using Dietary Diversity Score and Food Group Production Diversity Score

As a secondary analysis, survey-weighted linear regression was conducted using women's dietary diversity score (WDDS) as a continuous outcome. Table 5 shows that FGPDS (household food group production diversity score) was positively associated with WDDS. After adjustment, each

additional food group produced by the household was associated with a small but statistically significant increase in WDDS (β = 0.03; 95% CI: 0.01, 0.06; p <0.01).

WDDS was positively correlated with women with higher education, household size, female headed household, wealth index and negatively correlated with crop-land or aquaculture owned. Women who completed secondary or above education had 0.12- points higher WDDS compared to women with no education (95% CI: 0.002, 0.24; p=0.05). Each additional household member was associated with a 0.15-point increase in WDDS (95% CI: 0.12, 0.18; p < 0.01). Women of female headed households had 0.14 point higher WDDS than male headed household (95% CI: 0.28, 0.24; p<0.01). Compared with women from the poorest households, women from the richest households had a 1.28-point higher WDDS after adjustment (β = 1.28; 95% CI: 1.14, 1.42; p < <0.01). Women of households with crop-land or aquaculture had slightly less WDDS compared to households with only homestead (β -0.11; 95% CI: -0.21, -0.02; p=0.02).

Table 5: Factors associated with dietary diversity score of women of reproductive age

Variable	**Unadjusted** β	**95% CI**	**P value**	**Adjusted** β	**95% CI**	**P value**
FGPDS	0.02	-0.01, 0.04	0.21	0.03	0.01, 0.06	<0.01
Food Insecurity Experience Scale						
Food secure/mild insecurity	1.00 (ref)	-	-	1.00 (ref)	-	-
Moderate/Severe FI	-0.29	-0.41, -0.16	<0.01	0.07	-0.39, 0.18	0.21
Age group						
15-24 years	1.00 (ref)	-	-	1.00 (ref)	-	-
25-34 years	-0.09	-0.20, 0.03	0.13	0.027	-0.09, 0.14	0.64
35-49 years	-0.18	-0.28, -0.08	<0.01	-0.05	-0.16, 0.06	0.38
Women's Education						
No education	1.00 (ref)	-	-	1.00 (ref)	-	-
Primary	0.22	0.11, 0.33	<0.00	0.06	-0.04, 0.17	0.23
Secondary & Higher	0.50	0.36, 0.57	<0.01	0.12	0.002, 0.24	0.05

Women's Employment						
No employment	1.00 (ref)	-	-	1.00 (ref)	-	-
Agri & farm based	-0.162	-0.25, -0.07	<0.01	0.001	-0.1, 0.1	0.98
Non agricultural	-0.07	-0.23, 0.08	0.35	0.03	-0.10, 0.17	0.74
Marital status						
Unmarried/Divorced/Separated	1.00 (ref)	-	-	1.00 (ref)	-	-
Married	-0.10	-0.20, 0.01	0.09	-0.03	-0.14, 0.07	0.52
Woman participated in any SSN program						
No	1.00 (ref)	-	-	1.00 (ref)	-	-
Yes	-0.17	-0.34, -0.01	0.04	-0.09	-0.26, 0.08	0.31
Gender of Household head						
Male	1.00 (ref)	-	-	1.00 (ref)	-	-
Female	0.10	0.00, 0.20	0.05	0.14	0.28, 0.24	0.01
Household size	0.09	0.06 , 0.11	<0.01	0.15	0.12, 0.18	<0.01
Land type owned by household						
Homestead only	1.00 (ref)	-	-	1.00 (ref)	-	-
Has operated crop or aquaculture land	-0.12	-0.21, -0.02	0.02	-0.11	-0.21, -0.02	0.02
Household head education						
No Education	1.00 (ref)	-	-	1.00 (ref)	-	-
Primary	0.15	0.06, 0.24	<0.01	-0.01	-0.10, 0.08	0.89
Secondary & Higher	0.40	0.29, 0.49	<0.01	0.03	-0.07, 0.14	0.53
Household head employment						
No employment	1.00 (ref)	-	-	1.00 (ref)	-	-
Agricultural & farm-based	-0.34	-0.50, -0.19	<0.01	-0.10	-0.24, 0.05	0.18

Non-Agricultural	-0.14	-0.30, 0.01	0.06	0.02	-0.14, 0.17	0.85
Household Wealth Index						
Q1	1.00 (ref)	-	-	1.00 (ref)	-	-
Q2	0.39	0.28, 0.50	<0.01	0.39	0.28, 0.51	<0.01
Q3	0.61	0.49, 0.72	<0.01	0.62	0.50, 0.73	<0.01
Q4	0.84	0.72, 0.95	<0.01	0.87	0.76, 0.98	<0.01
Q5	1.20	1.07, 1.33	<0.01	1.28	1.14, 1.42	<0.01
Any severe shock in last 12 months						
No	1.00 (ref)	-	-	1.00 (ref)	-	-
Yes	0.077	-0.02, 0.17	0.11	-0.01	-0.09, 0.09	0.89
Improved sanitation						
No improved	1.00 (ref)	-	-	1.00 (ref)	-	-
Improved	0.28	0.19, 0.37	<0.01	0.06	-0.02, 0.14	0.11
Market access category						
High access <1 km or <10 min	1.00 (ref)	-	-	1.00 (ref)	-	-
Moderate access (1-2 km OR 10-20 min)	-0.08	-0.20, 0.05	0.22	-0.03	-0.13, 0.06	0.50
Low access (>2 km AND >20 min)	-0.25	-0.42, -0.09	<0.01	-0.13	-0.28 0.01	0.07

***Note**: Unadjusted coefficient estimated from separate bivariate linear regression analysis for each variable. Adjusted coefficient estimated from multivariable linear regression model. 95% CI and p-values are reported for both unadjusted and adjusted models. No multicollinearity detected (VIF < 5). Total number of observation = 3,687; All estimates are survey weighted; Survey weighted R^2 = 0.2210, F(32, 237) = 25.15. p value <0.05 is considered significant.*

Chapter 5: Discussion

Key findings

This study examined the association between household food-group production diversity and women's dietary diversity in rural Bangladesh using nationally representative BIHS 2018–19 data. To the best of our knowledge, this is among the first studies in Bangladesh to construct a minimum food-group production diversity indicator aligned with the ten MDD-W food groups and assess its association with women's minimum dietary diversity.

Prior studies in Bangladesh used simple counts of food crops, livestock and fish for measuring production diversification (B. N. Ahmed and Waibel 2019; H. Ali & Murshed-E-Jahan, 2025; Kabir et al., 2022; Khandoker et al., 2022; Alam et al., 2023; Uddin 2025). This study examined the association between the dietary diversity and household's own food production diversity using a 10-food group standard among reproductive age women in rural Bangladesh. A similar study done in rural Uganda also found an association between 10 food group-based food production diversity indicator and minimum dietary diversity among women (Buzigi et al., 2025).

Discussion of findings

The findings show that dietary diversity among women of reproductive age in rural Bangladesh remains low. Only 37% women achieved MDD-W, and mean dietary diversity score was 4.24, reflecting an inadequate dietary quality in the rural women. Based on the BIHS 2018-19 survey, A. U. Ahmed et al., (2022) found that the prevalence MDD-W among women aged 19-40 years was 38.2%, which is similar to our findings. Inadequate diversified diets among reproductive-age rural women are also reported by neighboring countries (Baxter et al., 2021; Brazier et al., 2020b; M. H. Islam, Nayan, et al., 2023; Shrestha et al., 2021; Weerasekara et al., 2020). Similarly, a community-based study in rural north-western Bangladesh among lactating mothers found WDDS 3.9 and MDD-W 29.7% (Shaun et al., 2022). In contrast, Roy et al. (2022) reported a higher mean of WDDS of 4.63 among women of smallholder farming households in northwest Bangladesh with a higher overall prevalence of MDD-W (46.4%). A separate study on the southern coastal island of St. Martin found similar MDD-W prevalence (40%) with a mean WDDS of 4.25 (M. H. Islam, Jubayer, et al., 2023b). All of these studies from rural Bangladesh context echoes the nutritional deficit among rural women in Bangladesh.

This dietary deficit among women has important public health implications. As MDD-W is used as a proxy indicator for micronutrient adequacy, the study findings indicate that 1 in 3 women of our sample are likely to achieve adequate intake of essential micronutrients. The consumption pattern observed in our study suggests that rural women mostly consume starchy foods such as grains/cereals and vegetables with limited amounts of animal source proteins including meat/fish, eggs and dairy products. This dietary pattern may contribute to inadequate intake of key micronutrients. Evidence from panel analyses of BIHS data showed that despite improvement in dietary diversity across the years, diets largely remained unbalanced (A.U. Ahmed et al., 2022).

This study found a statistically significant but modest association between food production diversity and dietary diversity. Households that achieved MFGPD had 34% higher odds of achieving MDD-W. However, using continuous WDDS as an outcome, the association with FGPDS is significant but weak. The coefficient of $\beta = 0.03$ suggests that with every unit increase in food group produced, there will be a 0.03 unit increase in food group consumed. This is consistent with the meta-analytic conclusion of Sibhatu & Qaim (2018) that production-diet link is generally weak across LMICs. The positive association between agricultural production diversification and intra-household dietary diversity is also found in another panel data analysis in Bangladesh, showing a positive association with a high impact of diversification among women and children (Alam et al., 2023). However, the production diversity does not necessarily improve dietary diversity, which can be further illustrated by the production-consumption gap observed in this study. Despite almost 70% of households producing eggs, only 1 in 5 women reported consuming egg during their 24 hour recall period. A cluster-randomized control trial in Sylhet evaluating Homestead Food Production intervention found that although the intervention increased the poultry production, it mediated only 12% of the intervention's impact on egg consumption (Lambrecht et al., 2023). This commodification of egg over household consumption tells us that the difference between household production and consumption is merely not a supply-demand gap, rather a behavioural and structural issue.

Similar production-consumption gaps are seen for food groups such as meat/fish, other fruits, despite households producing these items, the consumption among women remains significantly low. However, the consumption of staples such as grains/cereals and vegetables exceeded

household production, which can be related to market purchase behaviour (Sibhatu & Qaim, 2018). Proximity to markets play a positive role, with easier access to a wide range of food products enabling women to consume more diverse diet regardless of their own production (Alam et al., 2023; Nandi et al. 2021). Households with good market access can have diverse diets even without significant production diversification (Koppmair et al., 2016; Sibhatu & Qaim 2018). We found the odds of achieving MDD-W was 27 % less among low market access households compared to high access ones (95% CI: 0.54, 0.98, p=0.04), showing the role of structural factors such as market access in achieving dietary diversity. Households producing a more diverse range of food groups may have greater availability of diverse foods. However, the modest association suggests that production diversity alone is not sufficient to ensure women's dietary diversity. Furthermore, in our study households with operated crop land or aquaculture were negatively associated with dietary diversity, compared to those with only homestead. Foods produced in the homestead may have more impact on diet than operated farmlands or aquaculture through both direct consumption and indirect income pathways. (Dusingizimana et al., 2024; Lambrecht et al., 2023; Waid et al., 2023). Agricultural households may use operated crop land and aquaculture to generate income, by producing both food and non-food products which are then sold to markets (Sibhatu et al., 2015; Usman et al., 2022). These findings across studies suggest women's consumption may be shaped by market access, and affordability alongside production diversity (Sibhatu & Qaim 2018).

The present study clearly shows household wealth as a dominant determinant in association with women's dietary diversity. About 60% women from the richest households achieved MDD-W compared to only 17% from the poorest ones. Even after adjustment, the odds of meeting MDD-W were 8 times higher among wealthiest households than the poorest, suggesting that dietary diversity may depend more on food access and affordability than on own production alone. This relationship between wealth and food consumption is well established in food systems literature. Research suggests that women from wealthier households eat more diverse diets (Harris-Fry et al., 2015b; Saaka et al., 2021; Shestha et al., 2021; Yeneabat et al., 2019;). Furthermore, wealthier households can invest more in production diversity by investing in land or livestock. However, wealth is linked to dietary diversity not only through affordability but also by influencing factors like education, sanitation, market access and food security. These factors shape what foods are available and how they are utilized, which in turn affects the women's diet quality (Dusingizimana

et al., 2024; Gartaula et al., 2024; Gupta et al., 2020; Harris-Fry et al., 2015; Mascareñas-García et al., 2024). Household size was also positively associated with MDD-W (AOR: 1.13). Although most studies have linked larger households with lower dietary diversity, one cross-sectional study in a similar rural context found that higher household size was associated with slightly higher mean dietary diversity at household level (Harris-Fry et al., 2015). However, intrahousehold diversity can be different than household diversity (Harris-Fry et al., 2017). In rural Bangladesh, larger households are often associated with multiple earners and benefit from shared food resources contributing to an overall diverse diet (Prachee et al. 2025). However, research also shows larger households in resource constraint settings may be associated with higher food insecurity, indicating that different impacts may be seen based on food context (Farzana et al., 2017; Owoo, 2020).

Consistent with prior studies, dietary diversity score was higher among women with secondary or higher education than those with no education (ß: 0.1295% CI: 0.002, 0.24; p = 0.05). Educated women may have nutritional awareness for themselves and their families (Miller et al., 2017; Shourove et al.,2023). It may also provide women agency to decide what food to buy as well as give autonomy with more negotiating power (Shourove et al.,2023; Thorne-Lyman et al., 2009). Our study also found that women of female headed households had a better dietary diversity score than male headed households (ß:0.14; 95% CI 0.28, 0.24, p <0.01). This can be attributed to women's autonomy over resource allocation and purchase, as studies show women with control over assets and participation in purchasing decisions can improve dietary diversity (Shourove et al., 2023; Sinharoy et al., 2017; Sraboni et al., 2014). However, female headed households are more likely to be food insecure than male headed households, as they are actively burdened in managing household responsibilities alongside working outside (Mallick & Rafi, 2009). These findings suggest that women's diet may be affected by factors beyond individual level (Harris-Fry et al., 2015).

A negative association between MDD-W and food insecurity was observed in the unadjusted analysis. Compared to food secured households, moderate to severe food insecure households were less likely to consume a diversified diet. This is consistent with other literature. A cross-sectional study from northwest rural Bangladesh saw significant and positive association between household food insecurity and low dietary diversity of women (Roy et al., 2022). A study on rural Mali by

Adubra et al., (2019) also reported a similar association between food insecurity and low dietary diversity. On the consumption side, food-insecure households are less likely to consume costly nutrition rich animal source food products such as dairy, eggs, meat/fish compared to starchy foods such as cereals and dark green leafy vegetables (Na et al. 2016). This is consistent with our observation that the consumption of dark green leafy vegetables and grains exceeds their household production. However, on the production side, food insecure households may be too resource constrained to diversify production or may sell those produce to cope during adverse times. Our bivariate analysis between food insecurity and production diversity also revealed that households with moderate to severe food insecure households were associated with inadequate production diversity, reflecting a dynamic relationship between dietary diversity, resources and food insecurity (Sinharoy et al., 2017).

Implications for Public Health Policy and Practice

The findings suggest that nutrition-sensitive agriculture should promote diversified household food production, but production alone is not sufficient to improve women's dietary diversity. (Joachim et al., 2021). Programmes must ensure that diverse foods produced at household level are also retained, prepared, and consumed by women and other nutritionally vulnerable household members.

The observed production-consumption gaps, particularly for eggs, fruits, dairy, and other nutrient-rich foods, indicate the need to pair production diversification with behaviour change communication. Counselling should focus on home retention of diverse foods, women's consumption of nutrient-rich foods, intra-household food allocation, and the importance of regular consumption of animal-source foods, fruits, and vegetables. Programme models should therefore combine diversified production with nutrition counselling, women's empowerment, and household-level behaviour change. Nutrition-sensitive agriculture programs may be particularly relevant if they explicitly link production diversity with women's actual dietary intake.

The strong association between household wealth and dietary diversity also highlights that poverty reduction remains central to improving women's diets. Nutrition-sensitive social protection should be prioritised for poor and food-insecure households to improve both access to diverse foods and

capacity for diversified production. Overall, future interventions should move beyond increasing production alone and adopt an integrated approach that links agriculture, nutrition behaviour change, women's agency, and economic support.

Future research opportunities

Future research should focus on longitudinal or seasonal study designs to better understand how household production diversity influences women's dietary diversity over time. Studies should examine whether foods produced by households are consumed, sold, stored, or allocated differently among household members. Further qualitative and mixed-methods research is also needed to explore intra-household food allocation, women's decision-making over food, and barriers to women's consumption of nutrient-rich foods. These findings would help design nutrition-sensitive agriculture programmes that more effectively link diversified production with women's actual dietary intake.

Strengths & limitations of this study

The major strength of our study was the robust sample size and nationally representative dataset which ensures generalizability of our findings. The study also used validated tools like MDD-W and FIES. To ensure robustness both binary MFGPD and continuous FGPDS were constructed following the same 10 food group as MDD-W. Furthermore, secondary analysis using WDDS was done to check the consistency of findings. Survey weighted analysis was used to account for the complex survey design.

One limitation of the study is its cross-sectional nature, providing only a snapshot, making it impossible to establish a causal inference. However, cross-sectional studies may be a better source of data for policy judgments in the public health community than longitudinal studies when risk factors vary more across space at a fixed moment in time than at a fixed location across time (Markovitz et al. 2012). This study was based on secondary data where dietary data were collected only at a single point of time (single 24 hour recall method), so it didn't give us the yearlong dietary pattern. The potential risk of recall bias is another important limitation of the 24 hour

method where the exact amount of each food consumed cannot be investigated by enumerators. Nevertheless, the method is validated for low- and middle-income countries (Gibson et al., 2017).

Chapter 6: Conclusion and Recommendations

6.1 Conclusion

The study found a positive association between production diversity and dietary diversity of reproductive age women from a nationally representative sample. Women's education, gender of the household head, household size, wealth and type of land owned were also significant factors of women's diet suggesting a multimodal approach to ensure nutrient adequacy of rural women in Bangladesh.

6.2 Recommendations

Our study informs that it is possible to construct a dichotomous production diversity variable (MFGPD) based on MDD-W food groups to test association between production diversity and dietary diversity. The secondary analysis reinstates the fact that assessing production diversity based on the same food groups as MDD-W can generate evidence regarding production-diet patterns on a policy level. Policymakers should focus on integrating production diversity and dietary diversity in existing policy frameworks. Programmes should focus on promoting food group-based nutrition-sensitive initiatives to achieve adequate diversity among rural women in Bangladesh.

Declaration of GenAI Use

I, APURBO AHAM APU, declare that in preparing this assignment, I used ChatGPT (OpenAI, GPT 5.2, released on December 11, 2025) as a support tool to assist with brainstorming ideas, organising the structure of my writing, overcoming writer's block, and improving clarity, language or formatting in the text that I drafted myself. GenAI was not used to generate original arguments, interpret results, or produce final academic content. All substantive ideas, judgments, references, and conclusions are my own and have been independently verified in line with JPGSPH academic integrity guidelines.

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**Scribbr, an online citation manager was used for referencing (https://www.scribbr.com/citation/generator)*

Appendix:

Tables

Table A : BIHS Modules used for this study

Module	**Name**
Module A	Sample Household and Identification
Module B	Household Composition and Education
Module D	Own Household Assets
Module G	Roster of land and pond/water bodies owned or under operation
Module I	Summary of Agriculture Production and Food grain stock
Module K	Livestock and Poultry
Module L	Fisheries
Module R	Sanitation and Water
Module S	Access to Facilities
Module T	Economic Events/Shocks
Module U	Participation in Social Safety Net Programs
Module W	Anthropometry, Health and Illness
Module X	Household Food Consumption and Food Security